Advanced Hybrid On-Board Science Data Processor - SpaceCube 2.0

ESTO Earth Science Technology Forum
June 23, 2010

Tom Flatley – Branch Head
NASA/GSFC Science Data Processing Branch

On-Board Science Data Processing

ESDS On-Board Processing

- Data Volume Reduction
- Compression
- Calibration / Correction
- Classification
- Product Generation
- Autonomy
- Event / Feature Detection
- Real-time / Direct Broadcast

Hybrid Science Data Processing

- CPU
- FPGA
- DSP

GSFC SpaceCube On-Board Processor

- 10x-100x computing performance
- Lower power (MIPS/watt)
- Lower cost (commercial parts)
- Radiation tolerant (not hardened)
- Software upset mitigation

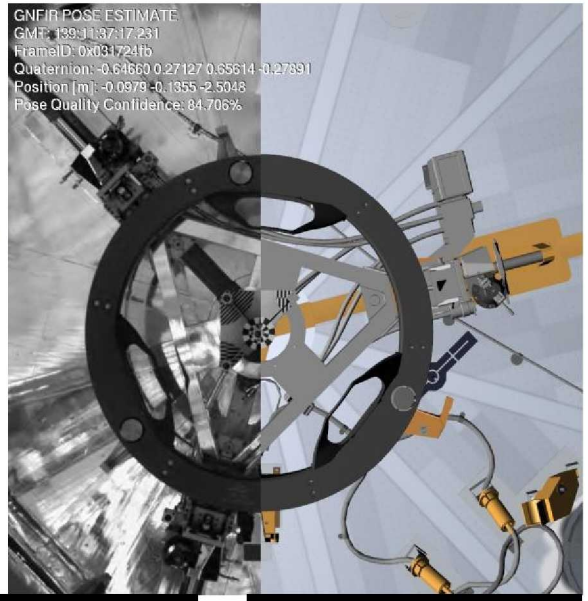
On-Board Image Processing

STS-125 Payload Bay

Long Range Camera on Rendezvous

Flight Image | RNS Tracking Solution

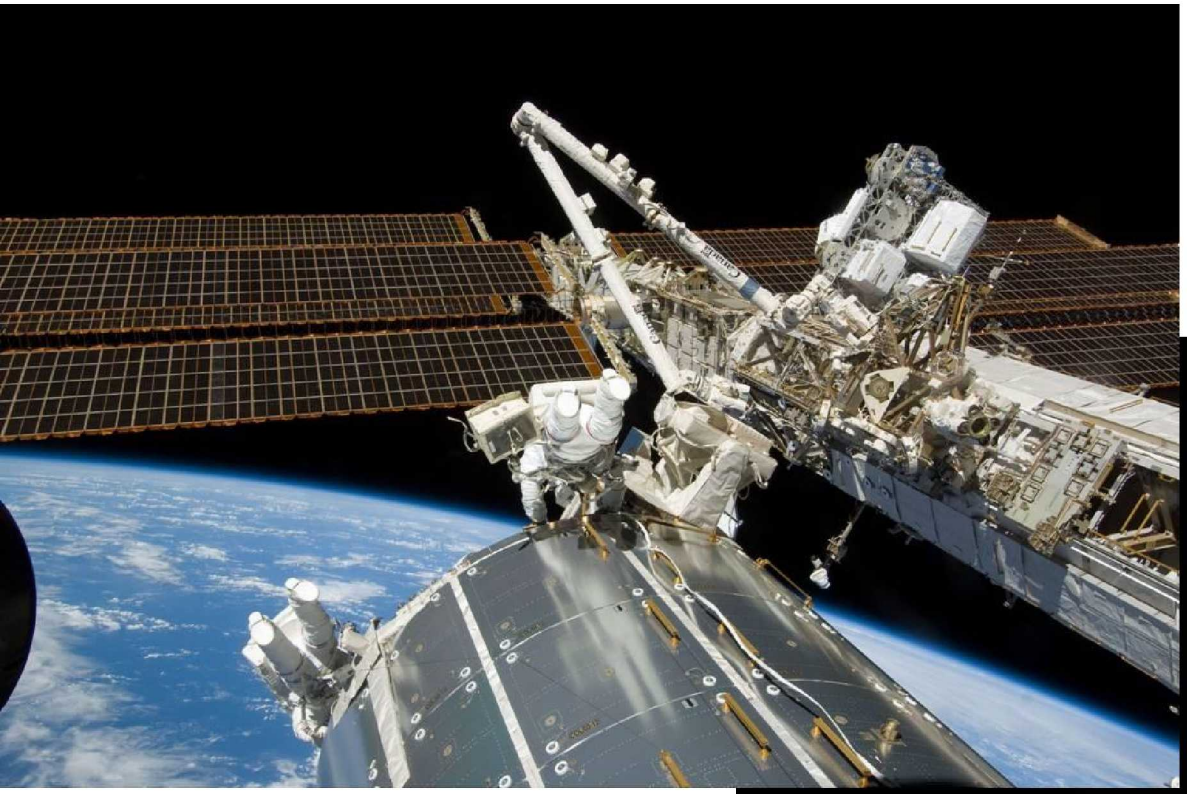
Short Range Camera on Deploy



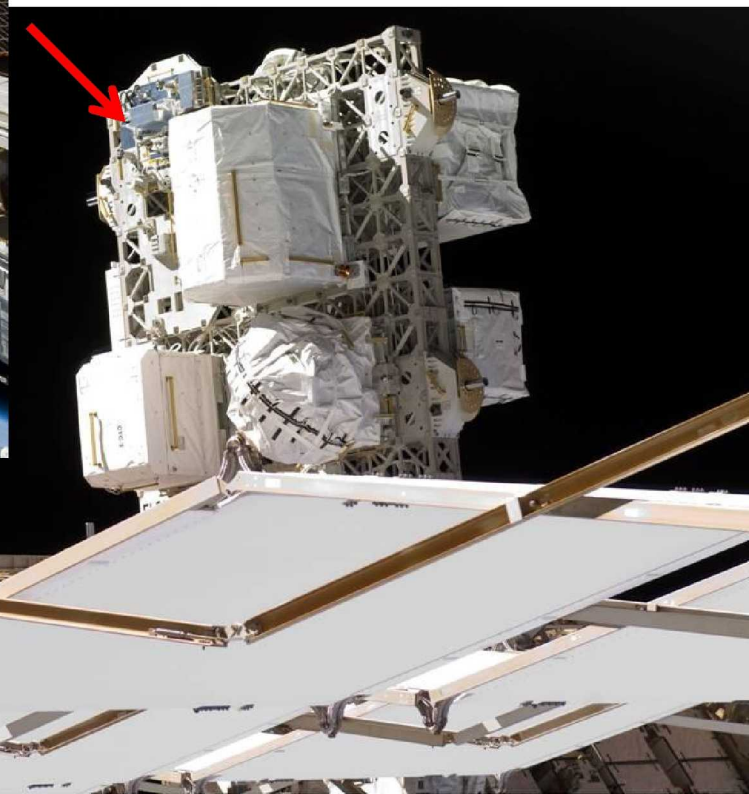
Flight Image | RNS Tracking Solution

GSFC SpaceCube 1.0a - Hubble SM 4 (May 2009):
- Autonomous Rendezvous and Docking Experiment
- Hosted camera AGC and two Pose algorithms

Software Upset Mitigation

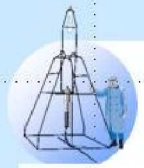


GSFC SpaceCube 1.0b (Nov 2009):
- "Radiation Hardened by Software" Experiment
- Autonomous Landing Application
- Collaboration with NRL



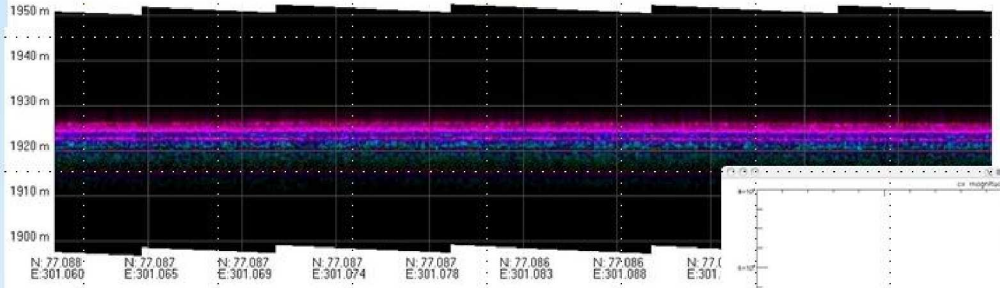
ISS Orbit	
Days Up	157 days 2 hours
Total SEUs	56.00
Avg SEUs/FPGA	14.00
Avg SEUs/FPGA/Day	0.09
Avg SEUs/FPGA/Week	0.62
Avg SEUs/FPGA/Year	32.55

On-Board Data Reduction



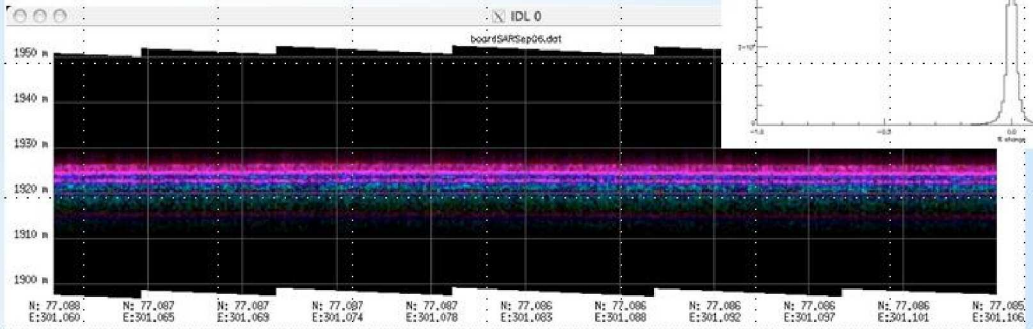
Accomplishments

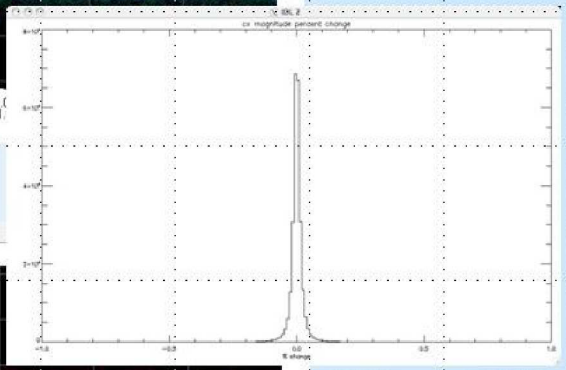
SAR Nadir Altimetry Results (FY07)



Original IDL Output

SpaceCube Output





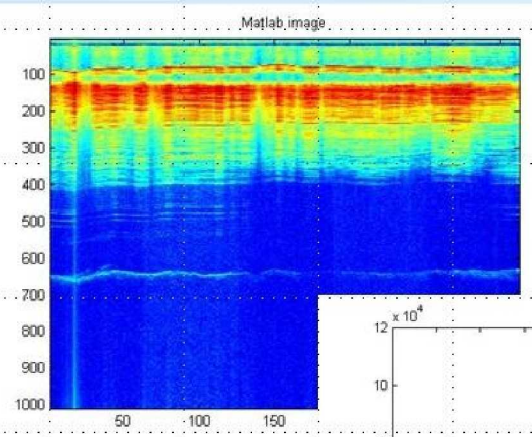
Difference < 0.1%

On-board processing yields lossless 6:1 data volume reduction

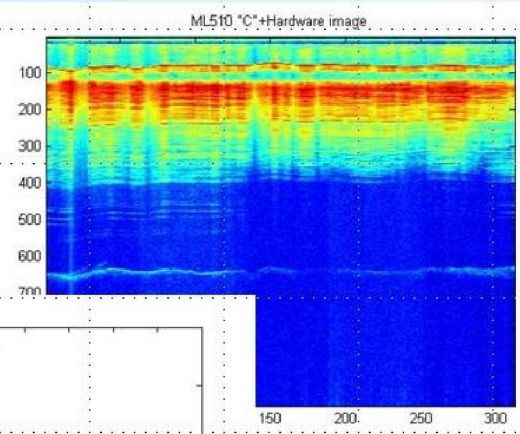
On-Board Data Reduction

Accomplishments

SAR Mapping Results (FY09)

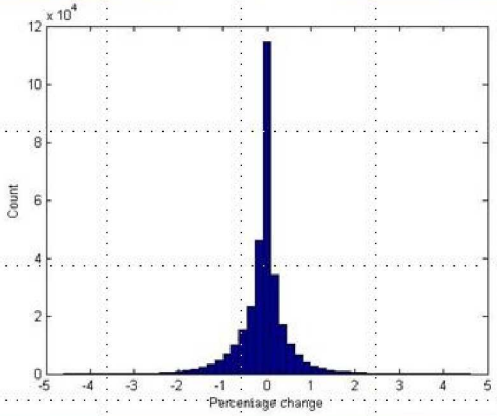


Original Matlab Output



SpaceCube Output

On-board product generation yields factor of 165x data volume reduction



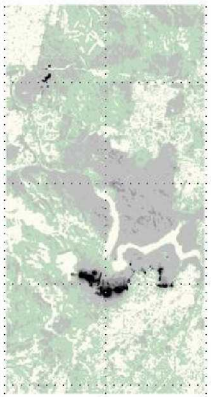
Difference < 1%

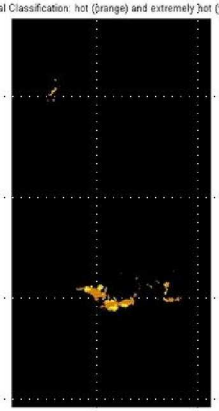
NASA GODDARD SPACE FLIGHT CENTER

On-Board Products

Accomplishments

California2007Oct23-bands33-43-155.jpg

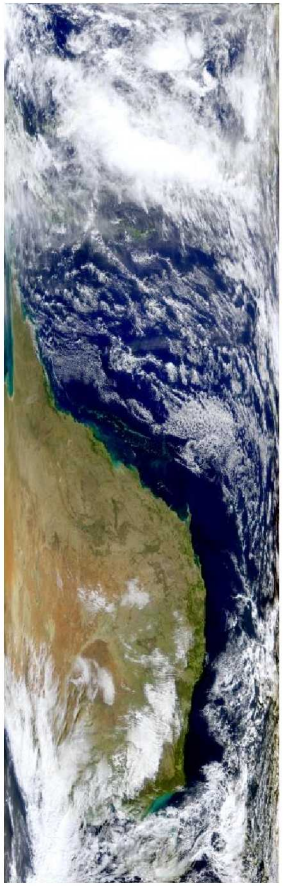


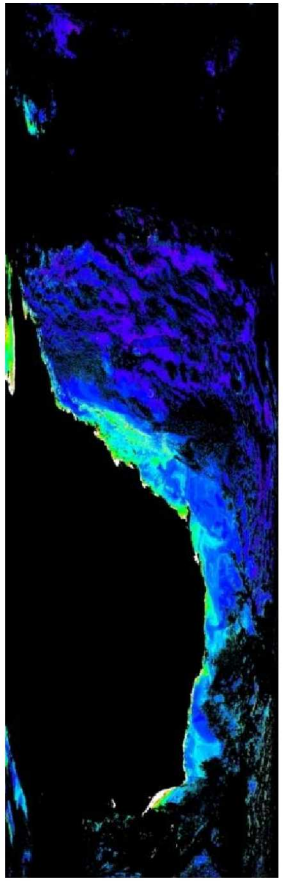


On-Board Products

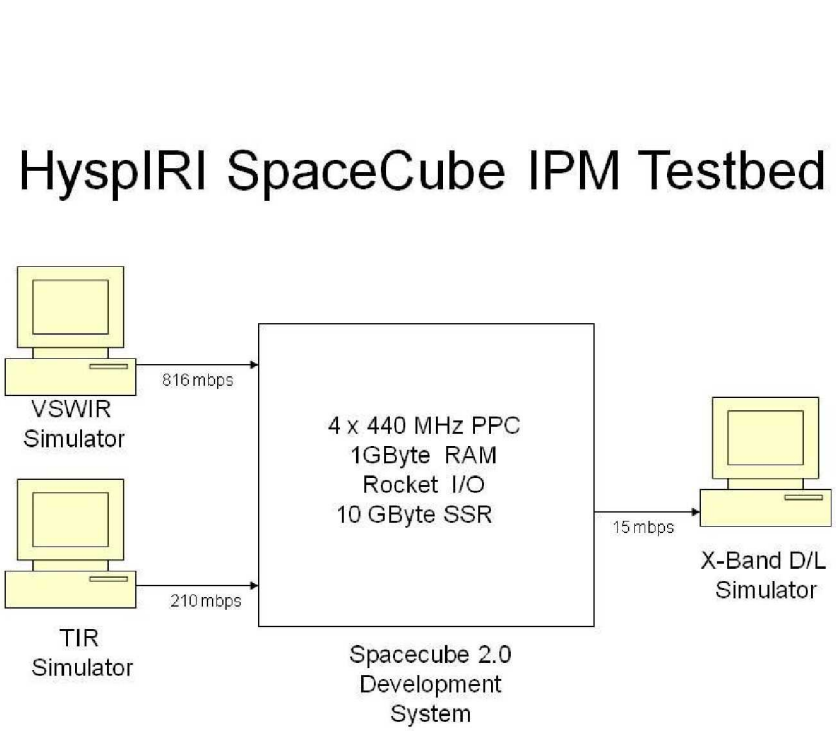
NASA GODDARD SPACE FLIGHT CENTER

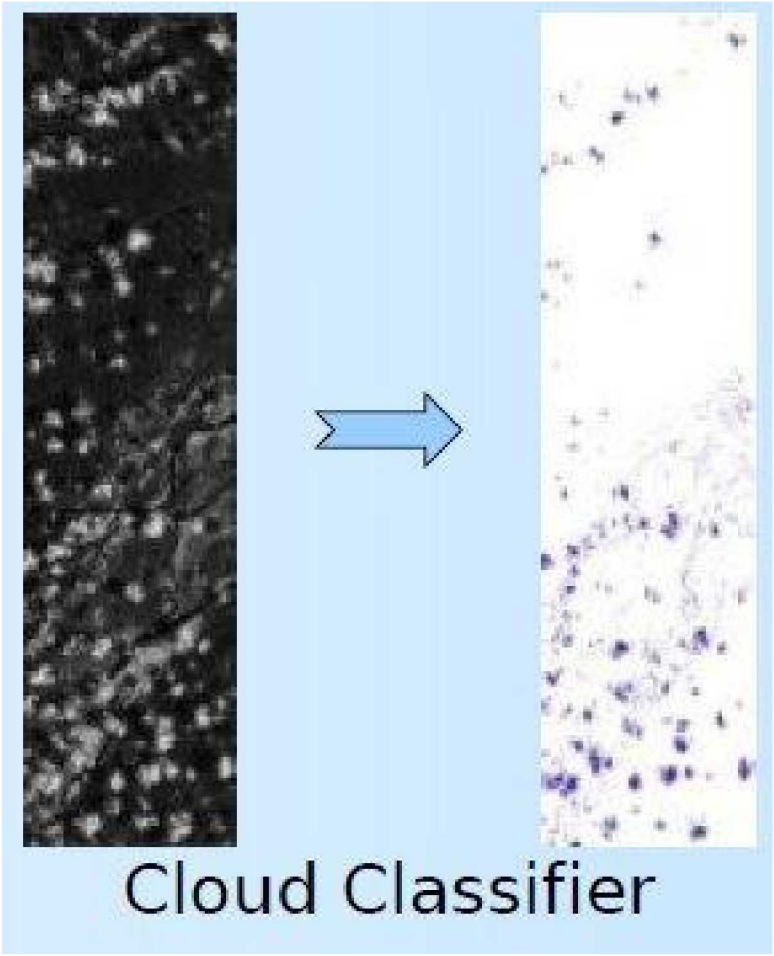
- Classification
- Product Generation
- Event Detection



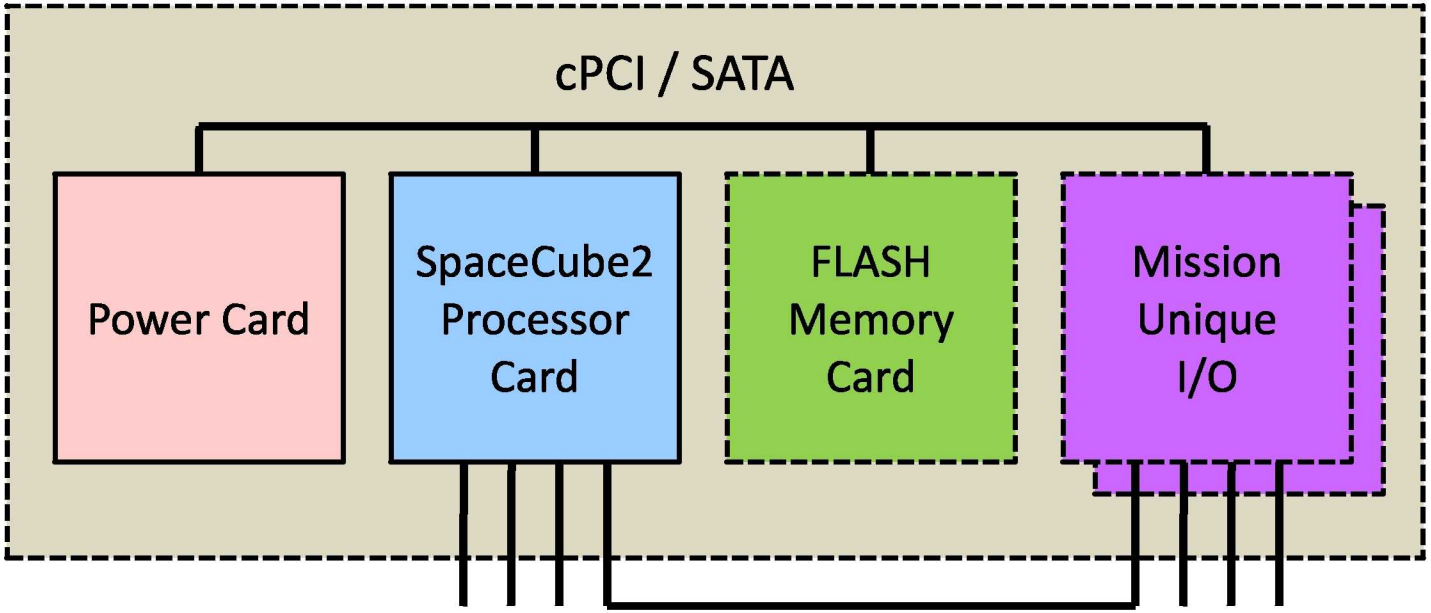


HyspIRI Demonstration Testbed





SpaceCube 2.0 Block Diagram



Spacewire / LVDS / MGT / GigE / Mission Unique High-speed

Standard 3U Card Form Factor
Nominal Box Level Parameters:
Size 5”x5”x7”, Weight 10-15 lbs, Power 10-20 watts

Processor Comparison

	MIPS	Power	MIPS/ W
MIL-STD-1750A	3	15W	0.2
RAD6000	35	10-20W	2.33[1]
RAD750	300	10-20W	20[2]
SPARC V8	86	1W[3]	86[3]
LEON 3FT	60	3-5W[3]	15[3]
GSFC SpaceCube 1.0	3000	5-15W	400[4]
GSFC SpaceCube 2.0	5000	10-20W	500[5]

Notes:
1 – typical, 35 MIPS at 15 watts
2 – typical, 300 MIPS at 15 watts
3 – processor device only ... total board power TBD
4 – 3000 MIPS at 7.5 watts (measured)
5 – 5000 MIPS at 10 watts (calculated)